Progress Report

Mini-Solar Power Station

SD1203

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1. Objectives

The Mini-Solar Power Station will consist of two subprojects. The first subproject was to construct a satellite tracking system. The Satellite Tracker will contain a satellite dish covered with a reflective Mylar material, but it will also be convertible to allow for a solar panel to be easily installed. The satellite dish will track the sun ensuring that a maximum amount of sunlight will be collected at all times. When the dish does not have the solar panel installed, the reflective Mylar material will focus all the sunlight to the dish's focal point. A hollow copper coil tube, which contains continuously running fluid, will be placed at the focal point. As the sunrays are reflected and focused at the copper coil tube, essentially at one point, the copper coil will begin to heat up which will consequently heat the fluid inside the coil. Thermal insulated tubing will connect the copper coil to a heat exchanger, so that the heat from the liquid can be measured. Using an NI USB 6008 DAQ, the temperature data will be plotted in real time using LabVIEW. When the solar panel is installed, the energy obtained will charge a 12-volt battery. We intend for the satellite tracker to be self-sustaining, meaning the energy collected will charge a 12-volt battery which will run the system. This will be accomplished by having one battery (charged) run the system, and one battery being charged in the process. The batteries will be interchanged when necessary. The charged battery will also run a 300-watt inverter so common household appliances can be used. Satellite motor operation is controlled using a PIC microcontroller and H-bridge IC's, and was coded in C.

The second subproject includes constructing a mechanical fixture containing a heat/light source to simulate the rising, setting, and latitudinal movements of the sun. The fixture will be composed of $\frac{3}{8}$" steel pipe, a combination of pulleys, stepper motor, and a linear actuator to drive the heat bulb to mimic the suns movement. The fixture will be used in correspondence with the above-mentioned satellite dish and serve as a testing device to prepare the Satellite Tracker for operation outside and for demonstration purposes. A 250W infrared heat lamp will be used to represent the sun and will be the source of heat. A dimmer switch will used with the heat lamp, which will dim the heat lamp to represent cloud cover. The dimmer switch will be controlled using the PIC and Pulse Width Modulation (PWM). Temperature data will be collected and plotted in LabVIEW. With the dimming of the lamp, the decrease in temperature should be evident in the LabVIEW plotted data. Both motor control and dimmer switch are controlled by a PIC microcontroller, and programming was done using C. The final goal of the project is to have the mini-solar power station fully functional outside using natural sunlight.

2. Current status and obstacles

We believe we have gained considerable ground on our project during our final semester. We have a majority of the project constructed; currently we are troubleshooting and finalizing the construction of both the satellite tracker and the sun simulator. The satellite tracker foundation has been built and has been tested for functionality with the PCB from Advanced Circuits. The tracker tracks the most "intense" light, so for testing and demonstration purposes the lights must be turned off or dimmed in the room for most efficient tracking of intended light. As an example, if all lights are off the tracker will automatically turn towards the window if there is daylight, so the tracking system is sensitive. The tracker schematic and PCB were designed in Multisim and Ultiboard, and the PCB was ordered through Advanced Circuits. The PCB was received, and then that PCB was populated, tested, and shown to work great. `

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The sun simulator track and foundation have been constructed, and both motors have been mounted. The wood base has been sanded and stained. Also, the motor controller schematic and PCB were designed in Multisim and Ultiboard. The PCB was ordered through Advanced Circuits, then was populated, tested, and works great. The problems found are not too severe but have been found to be challenging. The current design utilizes four stationary pulleys and two sheave pulleys (for rolling the lamp on the track). The stationary pulleys are used to control and "track" the wire pulling the lamp. The problem is when the sheave pulleys are on the far end of either side of the track, the force needed to pull the sheave pulley back is completely horizontal. This horizontal force puts a large strain on the track and is currently being addressed. However, the geared stepper motor (which Jeff made from a washing machine gear box) has enough torque to pull the sheave pulleys. So, a few ideas are being considered. What needs to be done is a support needs to be added to the wire so the force on the wire is no longer horizontal. Obviously, this problem and solution are hard to put in to words so it will be shown to you during our meeting. Another problem recently encountered is with the linear actuator. A ball elbow joint is being used to relieve the tension caused when the track is being tilted, without this the motor would bind to stop. The joint worked great and provided full tilt movement in both directions, however for some reason the joint "stiffened" and now the motor seizes when the track is at a certain angle. Hopefully lubrication fixes this problem, if not we will have to order another ball joint (fortunately they only cost around $3). If the problem is not fixed or it persists with a new ball joint a new solution will have to be decided on. This was initially written Sunday November 28, 2012. Since then, a wire support was built to fix the "horizontal force" problem. This along with spring tensioners on the sheave pulley have allowed for full functionality of the movement of the sheave pulleys (lamp). Also, it was found the ball socket elbow was broken because I torqued the screw to much which made the elbow stiffen. Another ball socket elbow joint was ordered, so this problem should also be fixed.

The copper coils being placed on the satellite dish and in the heat exchanger have been coiled. For such an easy task it was painstakingly time consuming. The heat exchanger box was constructed and stained, it looks great. The schematic and PCB for temperature measurement was designed in Multisim and Ultiboard. The PCB was sent to the NDSU milling machine for fabrication. The PCB was milled, populated, and is currently being tested. A small enclosure was built for the PCB, and the PCB/enclosure was mounted onto the heat exchanger box. A LabVIEW program was written and operational with a bread boarded thermistor circuit, testing with the PCB thermistor circuit is currently underway.

A circuit for the dimming/brightening function of the sun simulator has been designed and built on a breadboard. We ran into problems alleviating a "strobing" effect that was happening with our light. The light functions as it was intended to in the sense that it does dim and brighten when prompted by the user, but the hardware we were using was not able to keep up with the PWM signals. This made our light appear to constantly flash on and off. A new circuit that will utilize different hardware components has been designed and built on a breadboard to remedy this issue. This design is in the process of being finalized, and we will have the PCB ordered for the new design soon.

The battery charger circuit has been completed and sent to the NDSU milling machine. We used a buck-boost to build the recharger system. Buck-boost can supply a stable voltage to charge battery. The only problem is we use the MC 33063a chip during our charger circuit and it will work after the supply voltage higher than 3V that comes from solar panel. As we know, we can't make sure that we have enough voltage supply to the recharge system and make it works because the intensity of illumination is uncontrollable in out of doors. We add a diode between charge battery and voltage output to prevent the current reflow to the system and break it. The voltage of output is 14.5 V and the current of output is about 0.225A.

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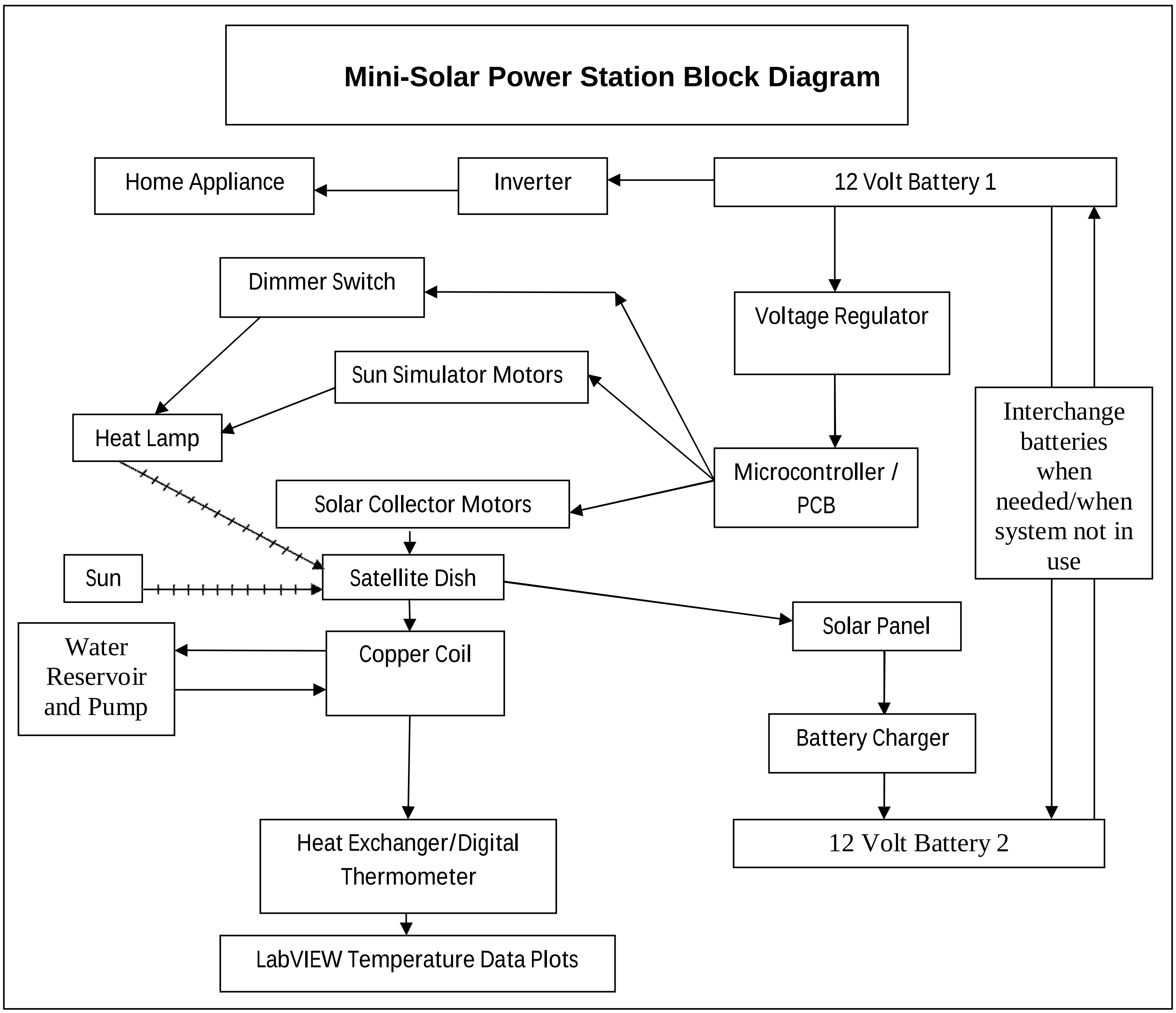
Reaming Tasks to Complete

1. Finalize tracker operation (Jace)
2. Make convertible mount for the satellite and solar panel (Jace)
3. Implement the copper coil on the satellite dish and we need to find the focal point (Jace)
4. Figure out how/where to place battery, heat exchanger, and etc. on the tracker base (Jace)
5. Stain/paint tracker base (Jace)
6. Order circuit enclosure for tracker motor controller (Jace)
7. Implement the inverter into the project. The inverter was supplied. (Jerry/Jace)
8. Complete sun simulator motor/track construction (Brian)
9. Complete the simulator base for demonstration day (Brian)
10. Test the heat exchanger with LabVIEW code, compare temperature readings with Fluke thermocouple to see how accurate the temperature readings are (Brian)
11. Complete the dimmer circuit, design circuit schematic, design PCB, send PCB for fabrication (Stephanie)
12. Order circuit enclosure for dimmer switch (Stephanie)
13. Figure out how to mount the lamp on the sheave pulleys (Brian/Stephanie)
14. Implement the dimmer circuit PCB with the sun simulator (Stephanie)
15. Populate battery charger circuit PCB once PCB is received (Jerry)
16. Test the battery charger circuit PCB (Jerry)
17. Order circuit enclosure for battery charger circuit (Jerry)
18. Mount the battery charger circuit onto the tracker (Jerry)

3. Updated Block Diagram



4. Updated Budget

The Mini-Solar Power Station is budgeted on a single sun simulator and satellite tracking system. The budget includes cost of purchased material and an approximate cost of materials not purchased that will be used in our project, as well as a total approximation of the cost we expect to incur for this project.

Project Name:	Mini-Solar Power Station					
Project Number:	SD1203					
Sun Simulator						
Mechanical Hardware	Cost/Unit	#	Purchased	Total Cost	Supplier	Notes
3/8" x 10' Steel Pipe	$21.10	2	X	$42.20	Tubes & Hose of ND	Part #: 03735
Wood (2x10-10' (1),2x4-8' (2))	$15.07	1	X	$15.07	Menards	
4 in Heavy Duty Tee Hinge	$3.87	2	X	$7.74	Grainger Industrial Supply	Part#: 1RCT3
R40 5" Dia., 250W, 120V Lamp	$21.84	1	X	$21.84	Grainger Industrial Supply	Part#: 1E295
Heat Lamp Dome	$18.00	1	X	$0.00	Free from NDSU	
Linear Actuator	$299.00	1	X	$0.00	Free from NDSU	LA34AGKS-4
Stepper Motor	$14.95	1	X	$0.00	Free from NDSU	57BYGH213
Ball Bearing Sheave	$11.91	2	X	$23.82	Grainger Industrial Supply	Part#: 5RTD5
Flat Mount Block Pulley, 2"	$7.73	2	X	$15.46	Grainger Industrial Supply	Part#: 4JX69
1/16, 50ft, 7x19 steel cable	$39.80	1	X	$39.80	Grainger Industrial Supply	Part#: 2TAY9
Solid State Relay	$30.00	1	X	$0.00	Free from NDSU	
Gear Box for stepper motor	$100.00	1	X	$0.00	Free from NDSU	Jeff Constructed
PCB	$50.00	2	X	$100.00	Advanced Circuits	Brian's & Jace's
Satellite Tracking System						
Mechanical Hardware						
Satellite Dish	$50.00	1	X	$0.00	Provided by Brian	
Stepper Motor	$14.95	1	X	$14.95	Free from NDSU	
Mylar	$11.99	1	X	$11.99	www.amazon.com	Part#: VMY130
DC Motor		1	X			
10' Copper Coil 3/8" OD	$8.74	1	X	$8.74	Menards	Item #: 675142
Brass Hose Barb	$1.99	4	X	$7.96	Menards	Model 17090298
Tetra Statuary Pump	$24.94	1	X	$24.94	Menards	
Tube to MPT connector	$2.67	4	X	$10.68	Menards	Model 17000122
PVC Insulation	$2.35	2	X	$4.78	Menards	Item #: 2KUE2
10' Plastic Tubing 3/8"	$8.49	1	X	$8.49	Menards	
12V rechargable battery	$30.00	3	X	$90.00	Free from NDSU	
NI USB 6008 DAQ	$169.00	1	X	$0.00	Free from NDSU	
Plastic Circuit Enclosures	$5.00	4	O	$20.00	Radio Shack	
350W Inverter	$29.00	1	X	$0.00	Provided by Brian	Walmart
Electrical Components						
ZTX1053a (npn transistor)	$0.98	20	X	$0.00	Free from NDSU	
MCP602 (OPAMP)	$0.62	16	X	$0.00	Free from NDSU	
PIC18F4620 (Microcontroller)	$7.92	5	X	$0.00	Free from NDSU	
ECS-200-20-46X (20 MHz Crystal)	$0.46	5	X	$0.00	Free from NDSU	
Photocell 80k-240kΩ	$1.86	15	X	$0.00	Free from NDSU	
LM7805 (5V voltage regulator)	$0.61	5	X	$0.00	Free from NDSU	
LM7812ACT (12V voltage regulator)	$0.69	2	X	$0.00	Free from NDSU	
Estimated Actual Cost of Project				$468.46		

5. Conclusion

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Obviously we still have a lot to do and less than three weeks to do it. We feel confident that we will complete the project and meet our requirements. With the Mylar reflective material, the heat collected will heat liquid that will run through a heat exchanger. Temperature data will be plotted real time using LabVIEW, so decrease in temperature due to cloud cover should be easily recognizable. When the solar panel is installed, we intend to convert this energy into electricity to charge two 12-volt batteries. The 12 volt batteries will then run a 300-watt inverter, which will allow for use of household appliances. The overall goal of the project is to have a fully functional mini-solar power station functioning outside using natural sunlight.